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KM SCIENCES

2017 FINAL REPORT

FINAL REPORT

of work performed by

KMSciences

on Contract N00014-87-C-2017

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Summery

KM Sciences performed work under this contract during the period from 01, May, 1987 through 31 May 1989. During this time KM Sciences made 28 trips to the University of California at Davis in support of the Naval Research Laboratories program of study of the effects of radiation on various types of advanced integrated circuits and integrated circuit test structures.

Outstanding results of this effort were the submission of a technical paper on the beam monitoring and dosimetry system to Nuclear Instruments and Methods, and the completion and utilization of a beam chopper system on beam line #2. In connection with the operation of the beam chopper, it was necessary to use radiachromic dye films for dosimetry. It was found that the radiachromic dye film offered an unique oppertunity to measure the beam profile with greater precision and speed than by previous methods. Hence, KM Sciences is developing a capability for scanning beam spots taken with radiachromic dye films.

The Beam Chopper

The beam chopping system was designed to meet certain performance specifications; beam pulse lengths from 0.1 seconds to 10 seconds with a rise time of less than 25 milliseconds, and this for beam currents capable of producing dose rates up to one megarad per second.

To meet the above specifications the chopper system was constructed with a slow acting,(about 1 second) water cooled beam stop which could withstand the maximum amount of beam power that the cyclotron was capable of producing. This was followed immediately downstream by a fast acting shutter system which was not cooled since it would not be exposed to full beam power for more than one second. The beam chopping system is shown in relation to the beam line in figure one. Figure two is a schematic drawing of the chopper system. It was necessary that the chopper have a large aperture because it was located far upstream near the exit of the quadrupole lens. The chopper was constructed with a one inch diameter aperture to ensure that it would not restrict any of the beam being focussed at the output end of the line. The fast shutter consisted of two aluminum blocks each one inch thick moved by solenoids. These blocks had to be thick enough to stop the most penetrating particle produced by the cyclotron. The sequence of operation was as follows: First, the slow stop was moved so that the one inch aperture cut in it would allow the beam to pass on to the fast shutters. When this stop reached the end of its travel it closed a circuit allowing the fast acting shutter to be fired. At the completion of the fast shutter cycle, the slow stop was returned to its initial position. This sequence of events was under the control of a timing circuit designed and built by Crocker Laboratory.

The fast shutters were driven by solenoids which were powered by large capacitors to achieve the required speed of operation. The shutter blocks were initially positioned so that one was blocking the beam while a second was out of the beam. The first block was then moved out of the beam and after a preset time the second block was moved into the beam. The total travel time of the block across the beam was measured to be 13 milliseconds. This travel time meant that the rise and fall of the beam current for a 0.1 second pulse length would be only about 25%.

The external controller for the chopper provides a continuously adjustable timing setting allowing pulse times from about 30 milliseconds to 9.8 seconds. It also provides a tune up mode in which both the slow stop and the fast shutters are open allowing the beam to be focussed or used in any other fashion required. In the chopped mode, the chopper is fired manually by means of a push button. A timing pulse coincedent with the firing of the fast shutter is provided on a BNC connector on the back of the control box.

In actual operation of the chopper it was found that a little of the beam leaked around the fast shutter during the time that the slow stop was in transit. An additional fixed stop was added between the slow stop and the fast shutter which eliminated this problem. This is shown in figure three.

High Beam Current Operation

To meet the requirement of dose rates up to one megaRad per second it was necessary to use 5 microamps of 67.5 MeV protons focussed at the exit window of beam line #2. Radiation surveys of the cyclotron facility were made with this beam in beam line #2. The results of the surveys indicated that there was no radiation hazard provided that once the beam exited it not be allowed an appreciable air path before being absorbed in an aluminum stop. A plastic box was constructed in which irradiations and beam alignment could be performed in an helium atmosphere. This method prevents the production of significant amounts of airborn radioactive species.

It was found that the cyclotron operators could provide a focussed beam spot of about one by two centimeters. This beam spot was quite reproducible when the operator exercises care in tuning. The beam spot was measured using radiachromic dye films. Dosimetry was achieved by means of one centimeter square films carefully centered over the device being irradiated. The beam was also monitored by operating the 617 electrometers in an external feedback mode. In this mode they integrated the beam current during the pulse providing a voltage proportional to the integral of the charge collected. In this way the SEM could be compared to the Faraday cup, and then used as a monitor of the charge delivered in any given pulse. The external feedback capacitors were calibrated using the 617 to measure the current and then recording voltage as a function of time produced by a current source.

The beam profile can be read after the fact using a piece or radiachromic dye film, however this method is also slow and tedious. A rotating wire scanner located just upstream from the SEM was modified by adding a second wire. This wire suitably positioned with respect to the first allows one to measure four different scans of the beam each at a unique angle perpendicular to the beam axis. KM Sciences together with Bruce McEachern of Crocker Labs were able to computer model this and show that a reasonable beam profile could be reconstructed from such information. Oscilloscope traces of the output of the rotating wire have shown four well seperated scans of a focussed beam of 67.5 MeV protons at 2 to 5 microamps. Software is currently being developed to aquire this information from a Tektronix 2430 oscilloscope.

Radiachromic Beam Profiling

During the past winter (1988-89) an opportunity arose to image the degraded beam with a radiachromic dye film. The film was exposed to a central does of one megarad. Two exposures were made and the films were read using a densitometer loaned to KM Sciences by The Desert Research Institute, University of Nevada, Reno. KM Sciences purchased a 600 nanometer band pass filter of 80 nanometers FWHM. Figure 4 shows the transmission of the filter together with the absorption of the radiachromic dye films. With this filter in place, the beam images were scanned and resulting beam profiles were calculated. These profiles were far superior to any made with TLD's. Hence, 50 4X4 inch radiachromic films were ordered for the purpose of measuring beam profiles. In May beam images were taken for a 21.4 MeV proton beam, and 11.8 MeV proton beam, and a 15.6 MeV alpha beam.

KM Sciences had ordered a densitometer similar to the one borrowed from DRI. This was received early in June and was used to scan the above mentioned beam images. The images taken at 21.4 MeV clearly showed a "hot spot" below and to the south of beam center. This was indicative of something wrong with the beam adjustment. In the future such beam profiles should be checked promptly and further investigations made into producing a "normal" beam image before proceeding with the experiment. This distorted image was more dificult to analyze but indicated that the central dose was probably about 6% lower than anticipated based on the "Normal" beam profile stored in the computer.

Table one shows the radiachromic profile data with the suspect 21.4 MeV data excluded. The averages agree quite well with the data taken in December of 88 out to 2cm radius. the 3cm radius is noticeably lower. This is most probably due to the fact that these measurements are mostly for rather high LET beams. Such beams will have more scattering both from the exit window and from the air path. This will produce a more pronounced fall off in intensity at the edges of the image and hence, a lower value at the three cm radius.

The New Densitometer

KM Sciences is currently modifying the Tobias Model TBX densitometer by installing the same filter used by Far West Technology in their film reader. A more convenient arrangement for positioning and moving the film being read is also being designed and constructed. It is anticipated that the entire system will be ready for use in the fall of 89.

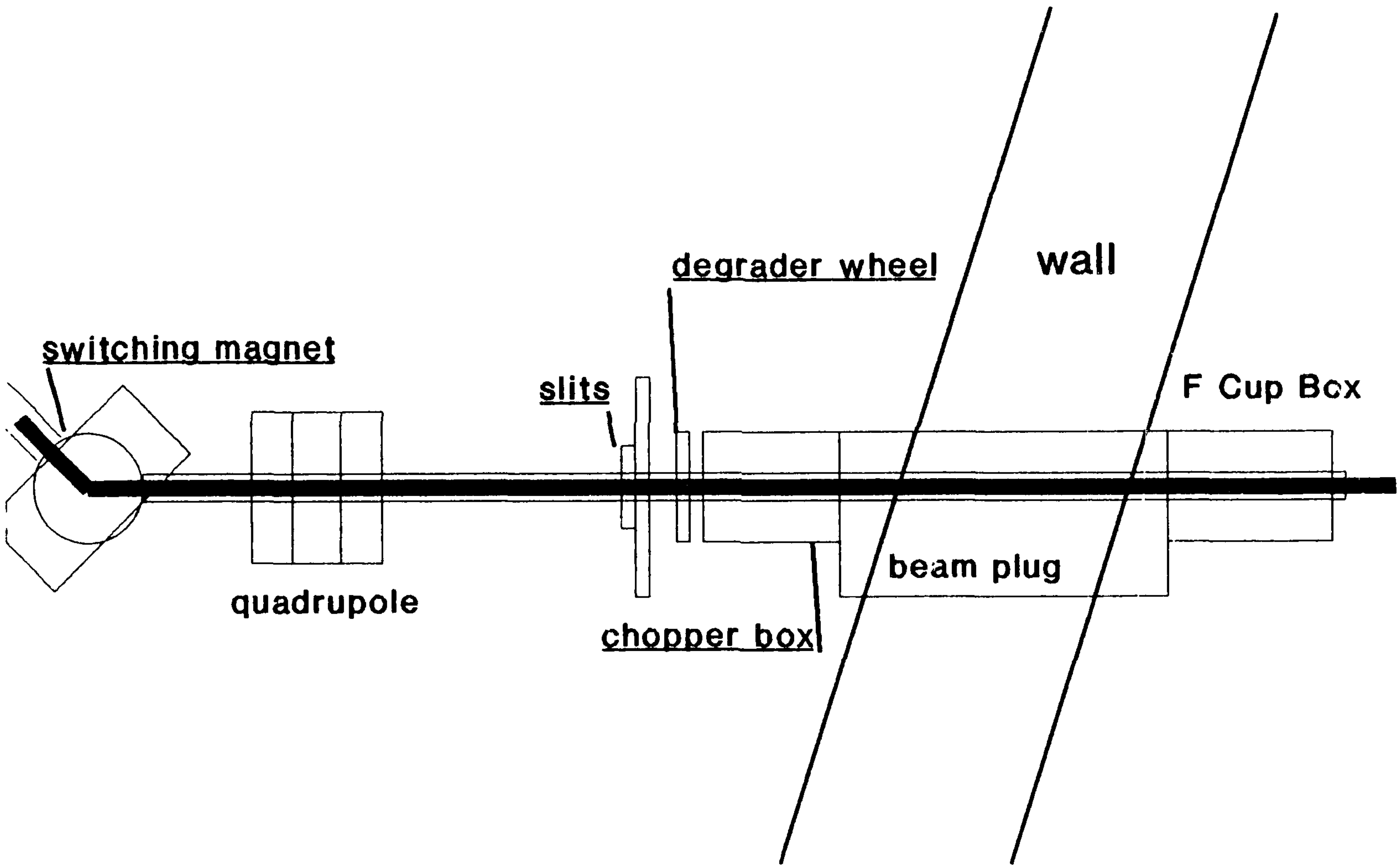
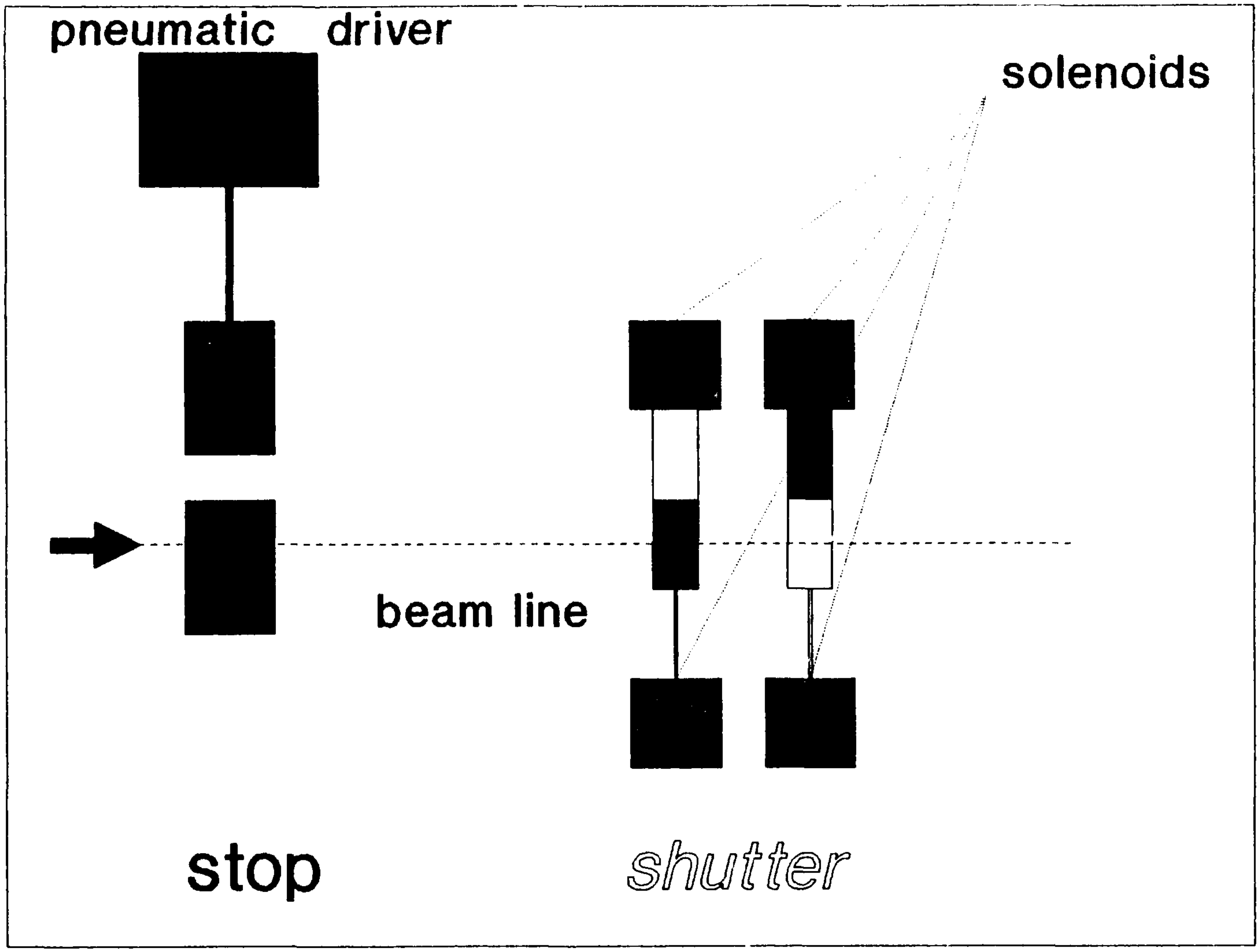


Figure one: Beam line #2 of the Crocker Cyclotron, showing the position of the Beam chopper.



chopper box

Figure two: The beam chopping system as originally constructed.

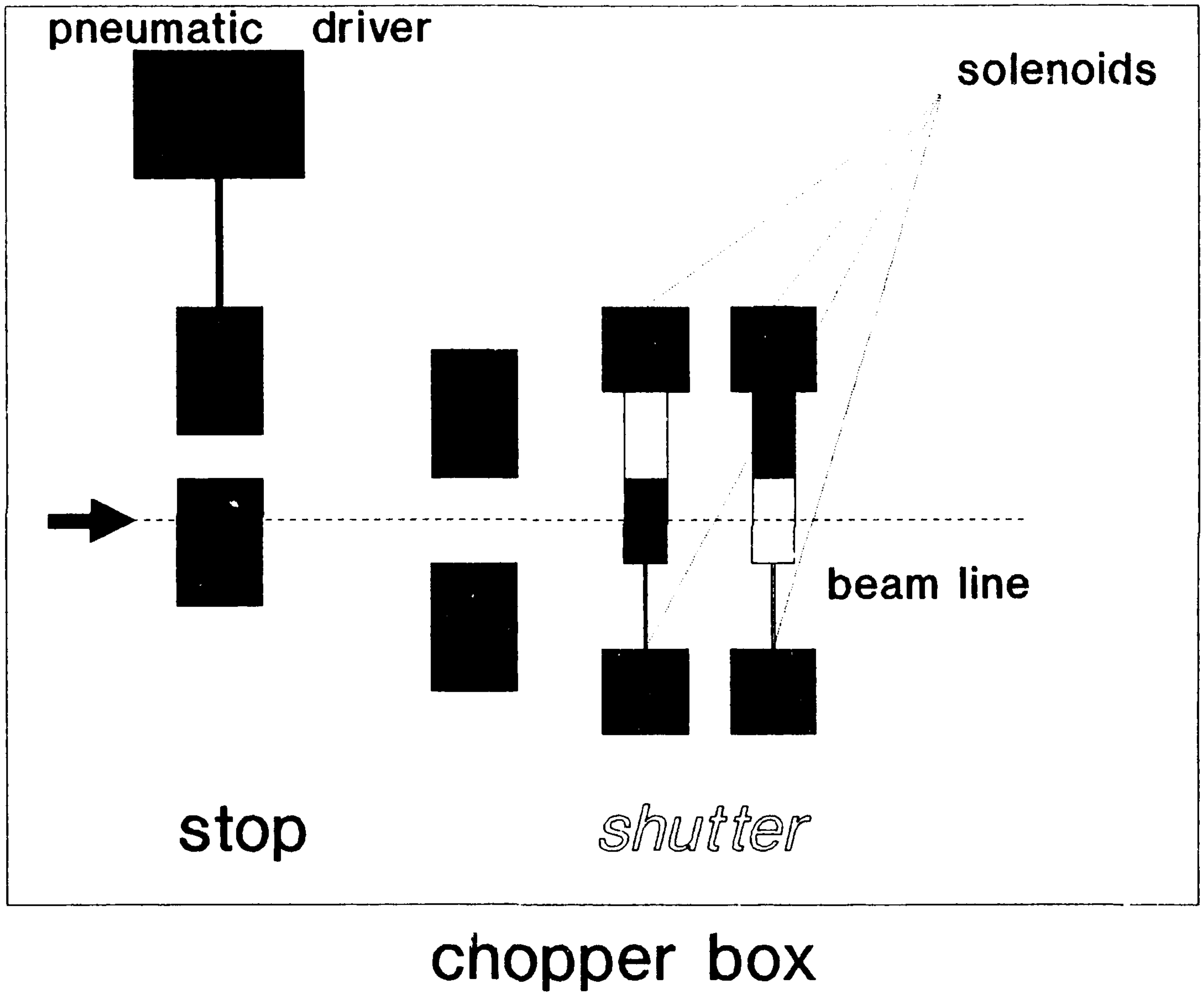


Figure three: The beam chopping system with a second stop added.

Filter Transmission
with dye absorption

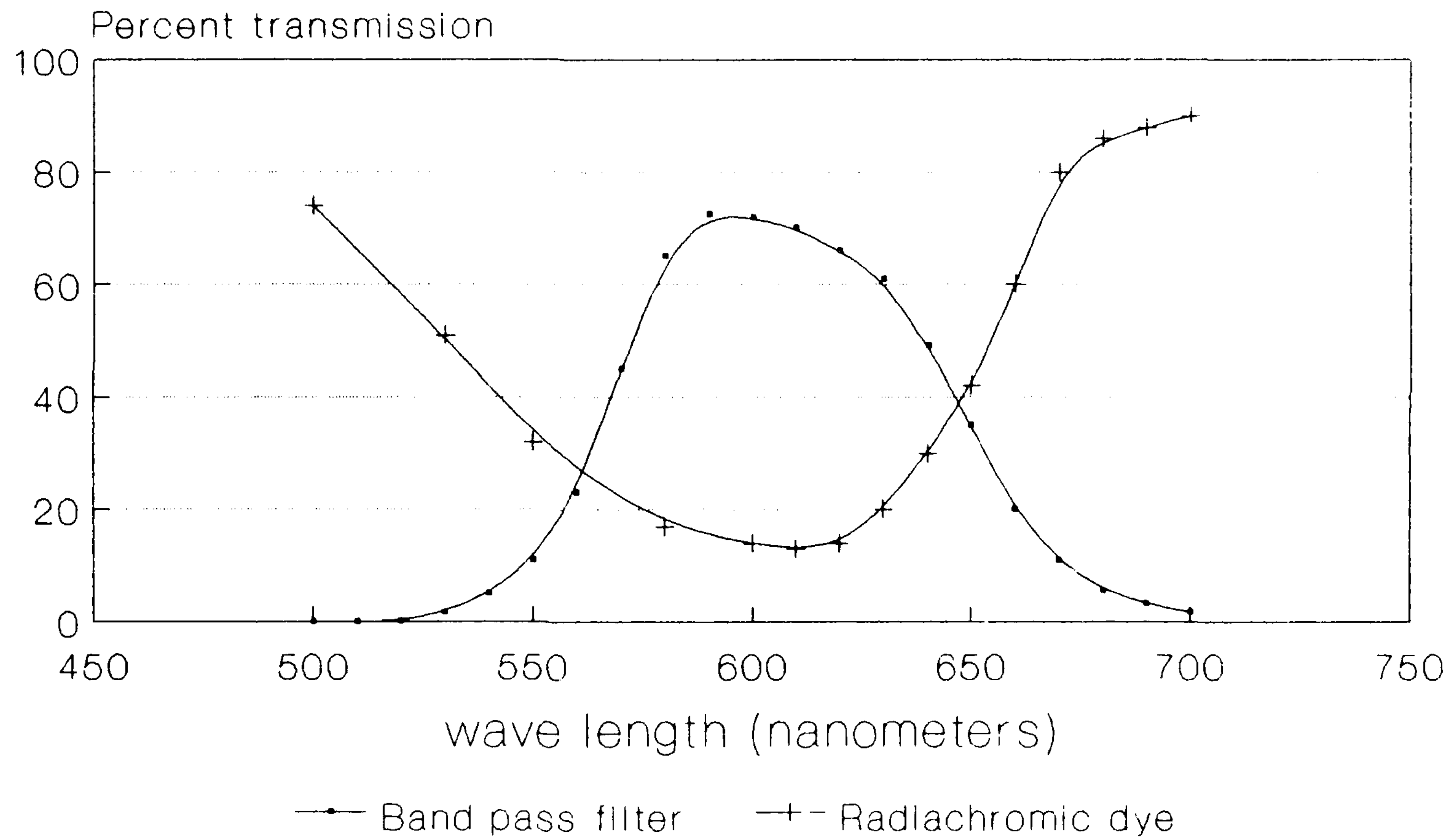


Figure four: Curves showing the filter transmission and the dye absorption.

RADIACHROMIC DYE FILM
Beam Profiles

date	particle	energy MeV	Center	R=1cm	R=2cm	R=3cm
12/15/88	proton	63	0.0300	0.0290	0.0269	0.02[illegible]3
12/15/88	proton	63	0.0305	0.0298	0.0274	0.02[illegible]1
05/17/89	proton	11.8	0.0294	0.0287	0.0268	0.01[illegible]1
05/17/89	proton	11.8	0.0307	0.0299	0.0275	0.01[illegible]0
05/18/89	alpha	15.6	0.0303	0.0297	0.0274	0.01[illegible]3
05/18/89	alpha	15.6	0.0303	0.0304	0.0270	0.01[illegible]
		averages	0.0302	0.0296	0.0272	0.0[illegible]1
		deviations	0.0004	0.0006	0.0003	0.00[illegible]7

Table one: Beam profiles measured using radiachromic dye films.